Pilot Study Workplan
for
Former Boeing Fabrication Operations Facility
St. Louis, Missouri

Prepared by:

The Boeing Company

BOEING®

July 9, 2001

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464C-5138-JWH
9 July 2001

BOEING

Mr. Patrick Quinn
Missouri Department of Natural Resources
Hazardous Waste Program
P.O. Box 176
Jefferson City, Missouri 65102

Encl: Pilot Study Workplan for Former Boeing Fabrication Operations Facility, St. Louis, Missouri (3 copies)

Injection well permit application

Dear Mr. Quinn;

Enclosed is the workplan for the pilot study specified in the approved Remedial Action Plan. The workplan addresses how Boeing will measure the ability of a Hydrogen Release Compound to reduce contamination at the former Boeing Fabrication Operations property. A copy of the injection well application is also enclosed for your reference. Two copies of the workplan will also be submitted to the U.S. EPA, Region VII.

Please contact me should you have any questions.

Sincerely,

Joe Haake

Joseph W. Haake, Group Manager
Environmental and Hazardous materials Services
Dept. 464C, Bldg. 220, Mailcode S221-1400
314-232-6941

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BOEING

Mr. Jerome Johnson
U.S. Environmental Protection Agency Region VII
901 North Fifth Street
Kansas City, Kansas 66101

Encl: Pilot Study Workplan for Former Boeing Fabrication Operations Facility, St. Louis, Missouri (2 copies)

Dear Mr. Johnson;

Enclosed is the workplan for the pilot study specified in the approved Remedial Action Plan. The workplan addresses how Boeing will measure the ability of a Hydrogen Release Compound to reduce contamination at the former Boeing Fabrication Operations property. Three copies of the workplan will also be submitted to the Missouri Department of Natural Resources.

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Table of Contents

Section		Page
1.0	**Introduction**	1
2.0	**Description of Current Conditions**	2
2.1	Facility Location	2
2.2	Environmental Setting	2
2.2.1	General Setting	2
2.2.2	Geology	2
2.2 3	Hydrogeology	3
2.2 4	Surface Water Hydrogeology	4
2.3	Investigation Activities	5
2.4	Summary of Investigation Findings	6
2.4.1	Soil Results	6
2.4.2	Groundwater Results	6
2.5	Source for Detailed Background Information	6
3.0	**Pilot Study Objectives and Procedures**	7
3.1	Objectives	7
3.2	Technology Description	7
3.3	Injection Well Permit Application	8
3.4	Subcontractors	8
3.5	Pilot Study Location	8
3.5.1	Injection Points	8
3.5.2	Monitoring Wells	8
3.6	HRC Injection	9
3.7	Equipment and Materials	9
4.0	**Sampling and Analysis**	10
4.1	Sample Collection Procedures	10
4.1.1	Groundwater Sampling	10
4.1.2	Soil Sampling	10
4.2	Quality Assurance/Quality Control Samples	10
4.3	Sample Management, Preservation, & Chain-of-Custody Procedures	10
4.4	Equipment Decontamination Procedures	10
5.0	**Health and Safety**	12
6.0	**Evaluation of Test Results**	13
7.0	**Schedule**	14

Table of Contents (continued)

1.0 Introduction

The information in this Pilot Study Workplan describes Boeing's plan to conduct a pilot study. This pilot study will measure the ability of a Hydrogen Release Compound (HRC) based remedial program to reduce the mass of trichloroethylene (TCE) and associated degradation products. The study will also assess the ability of HRC to address metal issues by precipitating/stabilizing chromium in groundwater and soil. The pilot study will be conducted at the former Boeing Fabrication Operations property, Building #27, which is now operated by GKN Aerospace Services. Results of the pilot study will provide detailed information and data to be used in support of the Boeing Remedial Action Plan.

2.0 Description of Current Conditions

2.1 Facility Location

The pilot study will be conducted at the former Boeing Fabrication Operations property, to the west Building 27. This property is currently owned by the United States Navy, leased to Boeing and subleased to GKN Aerospace Services who operates at the facility. The Facility is located at the northeast corner of the intersection of Lindbergh Boulevard and Banshee Road. It is bounded on the west by Lindbergh Boulevard, on the south by Banshee Road, and on the east by Coldwater Creek. With the exception of Building 220, McDonnell Boulevard bounds the northern portion of the Facility. Building 220 is located immediately north of McDonnell Boulevard. The Facility is located in the northwest quarter of Section 5, Township 46 North, Range 6 East, St. Louis County, Missouri.

2.2 Environmental Setting

A preliminary evaluation of the environmental setting at the Facility was initially prepared to better understand the framework for migration of any potential constituent releases and the potential effects on human health and the environment. This information is presented below.

2.2.1 General Setting

The Facility is surrounded by Boeing operations on the south, commercial and industrial facilities on the west and north, and Coldwater Creek on the east. According to information obtained from the MDNR, Division of Geology and Land Survey, no wells are located within a 1-mile radius of the Facility [RCRA Facility Assessment (RFA), 1995]. Surface water from the Facility drains toward Coldwater Creek, which flows along the Facility's eastern boundary.

2.2.2 Geology

Soil boring data indicate the presence of four general soil stratigraphic units overlying the bedrock surface at the Facility. These four general units are defined in descending order as the (1) Fill Unit, (2) Silty Clay Unit, (3) Silt Unit, and (4) Clay Unit.

Geotechnical lab results indicate that vertical hydraulic conductivity decreases with depth. Values ranged from 3.1×10^{-4} cm/sec for a sample collected from 10-12 ft bls (Silty Clay Unit) to 1.2×10^{-8} cm/sec for a sample collected from 75-76 ft bls (Clay Unit).

Fill Unit

Soil boring data indicate that a heterogeneous Fill Unit overlies the native materials at some portions of the Facility. Fill generally consisted of a mixture of materials either excavated at the site or brought in as clean fill during Facility construction/modification activities. Unit thickness varied between the buildings, but was typically less than 3 feet in thickness. For the majority of the Facility evaluated in this Phase 2 ESA, buildings and concrete/asphalt pavement overlie the Fill Unit.

<u>Silty Clay Unit</u>
Soil boring data indicate the presence of a Silty Clay Unit beneath the surface or the previously defined Fill Unit. These native materials generally consisted of olive-gray to reddish-brown, soft to stiff, silty clay. The silty clay often contained iron oxidation discoloration and numerous open, discontinuous channels, which are likely vertical root scars. Unit thickness generally ranged from 6-12 feet. Shallow groundwater in the Silty Clay Unit was typically perched on the underlying units, although depths varied dramatically (e.g. 3-5 ft bls at Building 22, 9-10 ft bls at East Parking Lot, 6-12 ft bls inside of Building 27, and not encountered from 0-16 ft bls for one location inside of Building 27).

<u>Silt Unit</u>
Soil boring data indicate the presence of a Silt Unit underlying the Silty Clay Unit. The native materials appear to be Lacustrine (lake-formed) in origin and are very thinly bedded with abundant organic debris (wood fragments and twigs). The silt is dark reddish-brown, medium stiff, and slightly moist. Unit thickness was generally between 1-3 feet. Due to the low moisture content of the silt and the presence of perched groundwater in the overlying Silty Clay Unit, the Silt Unit and underlying Clay Unit appear to act as an aquitard.

<u>Clay Unit</u>
Soil boring data from the deep groundwater monitoring wells indicate the presence of a Clay Unit underlying the Silt Unit. These native materials generally consisted of light to dark gray, stiff to very stiff, plastic clay. This unit was generally encountered between 15-20 ft bls and extended to a depth of approximately 80 ft bls. Within 2-4 ft above the top of the bedrock surface, the Clay Unit graded into a silty clay to clayey silt with coarse gravel intermixed in the clay matrix.

Based on interpretations from Phase 2 ESA boring results, previous investigations, and regional geological information, the Silt Unit and the Clay Unit are expected to be relatively uniform and continuous beneath the Facility and immediately surrounding area. As such, the units serve as an aquitard beneath the Facility, effectively limiting any vertical migration of groundwater.

2.2.3 Hydrogeology

As previously indicated, shallow groundwater was typically encountered in the Silty Clay Unit. However, this material has little potential to produce water as exemplified by the difficulties in acquiring sufficient sample volumes from temporary piezometers at Building Nos. 21, 27, and 29. Shallow groundwater was encountered at a range of depths for the various borings as summarized below for representative locations:

Building 22 - 3-5 ft bls;
Recycling and Hazardous Waste Areas - 5-6 ft bls;
East Parking Lot - 9-10 ft bls;
Building 27 interior - 6-12 ft bls;
Boring B27I3 - Not encountered from 0-16 ft bls.

As stated in the previous section, the Facility is underlain by low permeability clay and silt. Because of the low permeability of these units, groundwater quantities are generally low. The shallow groundwater table may be modified locally at the Facility due to the presence of buildings or parking lots. Groundwater elevation surface maps indicate general flow of shallow groundwater toward the east and Coldwater Creek. Given the low permeability and thickness of the unconsolidated deposits underlying the Facility, a direct connection to deeper bedrock aquifers is not expected.

Water was encountered in the deep wells near the top of bedrock in a clayey silt to silty clay that contained coarse gravel. Water levels recorded in the deep wells installed in the Clay Unit at approximately 70-80 ft bls indicate that the deep water-bearing unit is under artesian conditions. Artesian conditions exist when the water level in a well rises above the top of the unit and are indicative of a confined water-bearing unit.

The uppermost bedrock encountered in the area of the Facility is the undifferentiated Pleasanton, Marmaton, and Cherokee Groups of Pennsylvanian age. Shales, siltstones, sandstones, coal beds, and thin limestone beds are the dominant lithology of these three groups. Regionally, the Pennsylvanian-age groups have a total thickness ranging from 10-300 feet.

Underlying the Pennsylvanian strata is Mississippian-age limestone. The Ste. Genevieve Formation (0-160 feet thick), St. Louis Limestone (0-180 feet thick), Salem Formation (0 to 180 feet thick), and Warsaw Formation (0-110 feet thick) are all limestone and compose the upper portion of the Mississippian-age bedrock.

2.2.4 Surface Water Hydrogeology

General surface water drainage at the Facility is by overland flow to storm sewer intakes located across the Facility or to open drainage ditches that drain to storm sewers. The storm sewers discharge into Coldwater Creek at several locations. Coldwater Creek flows northeast within an underground culvert from the southwest side of Lambert-St. Louis International Airport, across the central portion of the airport, and the easternmost part of Tract I South. The creek flows within an open culvert north of Banshee Road along the eastern boundary of Tract I North. Coldwater Creek then flows northeast within this open culvert for several miles until it rejoins its original channel. The creek eventually discharges into the Missouri River. At its closest point, the Missouri River is approximately 3 miles to the northwest of the Facility.

Presently, approximately 90-95 percent of the surface area is covered with buildings, paved streets, paved parking lots, tank areas, and docks. Several of the aboveground structures associated with discontinued processes have been demolished, although concrete at or below grade remains. An extensive network of utilities including potable and service water lines, storm sewers, sanitary sewers, and other utilities (typical of an industrial facility) is located underground.

2.3 Investigation Activities

Initial Phase 2 ESA field activities were conducted in July-August 2000 (Phase 2A) to evaluate potential environmental impacts at the Facility. Supplemental Phase 2 ESA activities were conducted in September-October 2000 (Phase 2B) and December 2000-January 2001 (Phase 2C) to complete these delineation efforts. These activities included: soil boring installations, soil sampling and analyses, temporary piezometer/monitoring well completion, groundwater monitoring and analyses (shallow and deep water-bearing units), wipe sampling and analyses. Most of the Phase 2 field activities were completed on a site-specific basis for soil, groundwater, and surface evaluation purposes. A groundwater monitoring well network was also completed to assess groundwater conditions on a Facility-wide basis. Locations of the Phase 2 ESA soil borings, piezometers, and groundwater monitoring wells are referenced in Figure 2-1 of the Remedial Action Plan dated February 7, 2001.

The following general chronology of field activities was completed to fulfill the Phase 2A scope of work as outlined in the Phase 2 ESA Work Plan:

1) Installation of 40 investigative soil borings to assess geological and hydrogeological conditions beneath the Facility;
2) Installation of 36 temporary piezometers to assess hydrogeological conditions beneath the Facility;
3) Installation of 8 shallow groundwater monitoring wells to assess hydrogeological conditions beneath the Facility;
4) Sampling of subsurface soils utilizing continuous collection methods;
5) Collection of subsurface soil samples for field screening and laboratory analyses;
6) Collection of groundwater samples for field screening and laboratory analyses;
7) Collection of wipe samples for laboratory analyses; and
8) Monitoring of groundwater surface.

The following general chronology of supplemental field activities was completed to fulfill the Phase 2B scope of work as outlined in the Work plan Addendum for the Phase 2 ESA:

1) Installation of 19 investigative soil borings to assess geological and hydrogeological conditions beneath the Facility;
2) Installation of 3 piezometers to assess hydrogeological conditions beneath the Facility;
3) Installation of 15 temporary piezometers to assess hydrogeological conditions beneath the Facility;
4) Installation of 9 groundwater monitoring wells (4 shallow monitoring wells and 5 deep monitoring wells) to assess hydrogeological conditions beneath the Facility;
5) Sampling of subsurface soils utilizing continuous collection methods;
6) Collection of subsurface soil samples for field screening and laboratory analyses;
7) Collection of groundwater samples for field screening and laboratory analyses; and
8) Monitoring of groundwater surface.

The following general chronology of supplemental field activities was completed to fulfill the Phase 2C scope of work as outlined in the associated work plan:

1) Installation of 11 investigative soil borings to assess geological and hydrogeological conditions beneath the Facility;
2) Installation of 10 temporary piezometers to assess hydrogeological conditions beneath the Facility;

3) Installation of 3 shallow groundwater monitoring wells to assess hydrogeological conditions beneath the Facility;
4) Sampling of subsurface soils utilizing continuous collection methods;
5) Collection of subsurface soil samples for field screening and laboratory analyses;
6) Collection of groundwater samples for field screening and laboratory analyses; and
7) Monitoring of groundwater surface.

2.4 Summary of Investigation Findings

Upon completion of each stage of the Phase 2 ESA (Phase 2A, Phase 2B, Phase 2C), the analytical data were evaluated to delineate potentially impacted areas and guide the scope/extent of subsequent investigation activities. Conservative investigation threshold levels (ITLs) were established and utilized for these evaluative purposes. These ITLs were used as a preliminary means of focusing future efforts on the relevant constituents and areas of concern. The Remedial Action Plan developed preliminary remediation objectives (PROs) that represent values that incorporate both risk-based actions levels and site-specific background levels.

2.4.1 Soil Results

Phase 2A/2B/2C ESA analytical results for soil samples collected from the Facility indicate the presence of isolated constituent impacts to subsurface soils.

Phase 2A/2B/2C analytical results largely defined the nature and extent of constituent impacts to subsurface soils at the Facility. Constituent impacts to subsurface soils are referenced in Volume 3 of the Phase 2 ESA dated June 14, 2001.

2.4.2 Groundwater Results

Phase 2A/2B/2C ESA analytical results for the groundwater samples collected from specific portions of the Facility indicate the presence of constituent impacts to the shallow water-bearing unit.

Phase 2A/2B/2C analytical results largely defined the nature and extent of constituent impacts to subsurface soils and the shallow water-bearing unit at the Facility. Using ITLs as a comparative baseline, approximate delineation of constituent impacts to the shallow water-bearing unit are displayed in Volume 3 of the Phase 2 ESA, dated June 14, 2001.

2.5 Source for Detailed Background Information

As previously described, the content of this section was derived from the Boeing Phase 2 ESA Report dated June 14, 2001 that summarizes the investigation activities and results to date. The Phase 2 ESA Report should be reviewed to acquire additional background information regarding the Facility investigation.

3.0 Pilot Study Objectives and Procedures

3.1 Objectives

The In-Situ Pilot Study will demonstrate the ability of the injected Hydrogen Release Compound (HRC) to enhance biological activity under anaerobic conditions of the reductive dehalogenating microbes to dechlorinate TCE and other chlorinated aliphatic hydrocarbons. It will also demonstrate the ability to address the metal of concern, chromium, by precipitation/stabilization. The analytical results of the study will be used to provide detailed information in support of the Boeing Remedial Action Plan.

3.2 Technology Description

Chemical injection can be used as an in situ remediation technology to reduce constituent concentrations in soil and groundwater. One such technology involves HRC (Hydrogen Release Compound). HRC is a proprietary polylactate ester of Regenesis, Inc. that is specially formulated for slow release of lactic acid upon contact with water in the subsurface environment. HRC injection is designed to expedite the natural biodegradation process for subsurface soils and groundwater that have been impacted by chlorinated solvents.

Remediation of soil and groundwater using HRC injection typically involves installation of numerous injection points throughout the contaminated zone. This process involves the percolation or injection of this material to greatly enhance the reductive dechlorination process. The dechlorination process ultimately results in production of non-toxic compounds such as ethane or ethene.

Chlorinated solvents undergo biodegradation through three different pathways: 1) use as an electron acceptor (reductive dechlorination); 2) use as an electron donor (primary substrate); 3) co-metabolism where degradation of the chlorinated solvent provides no benefit to the microorganism but is simply fortuitous. In general, biodegradation of chlorinated solvents is an electron-donor-limited process.

The most important process for the natural biodegradation of chlorinated solvents is reductive dechlorination. The chlorinated solvent is utilized as an electron acceptor, and a chlorine atom is removed and replaced with a hydrogen atom. Because chlorinated solvents are utilized as electron acceptors during reductive dechlorination, an appropriate carbon source is required for microbial growth to occur. Reductive dechlorination has been demonstrated under nitrate- and sulfate-reducing conditions, but the highest rates of biodegradation occur during methanogenic conditions.

3.3 Injection Well Permit Application

McDonnell Douglas Company, a wholly owned subsidiary of The Boeing Company, will submit an application for an injection permit to the Division of Geology and Land Survey and the Water Pollution Control Program. Information will be provided as requested on Forms

UIC I & II along with the required permit fee. Two additional monitoring wells will be installed as part of the study; however, no permanent injection wells will be installed with the HRC application. Once Boeing has obtained the permit, a start date will be scheduled for the pilot study.

3.4 Subcontractors

Boeing will contract with an environmental engineering firm using a Missouri Registered Geologist to provide project management for the pilot study. A drilling contractor familiar with the HRC application process will be retained to inject the material within the pilot study location. Regenesis Inc. will provide the HRC product and technical support related to the application amount along with reviewing sampling analytical results. An off-site approved laboratory will perform all the required sampling analysis with the proper QA/QC controls.

3.5 Pilot Study Location

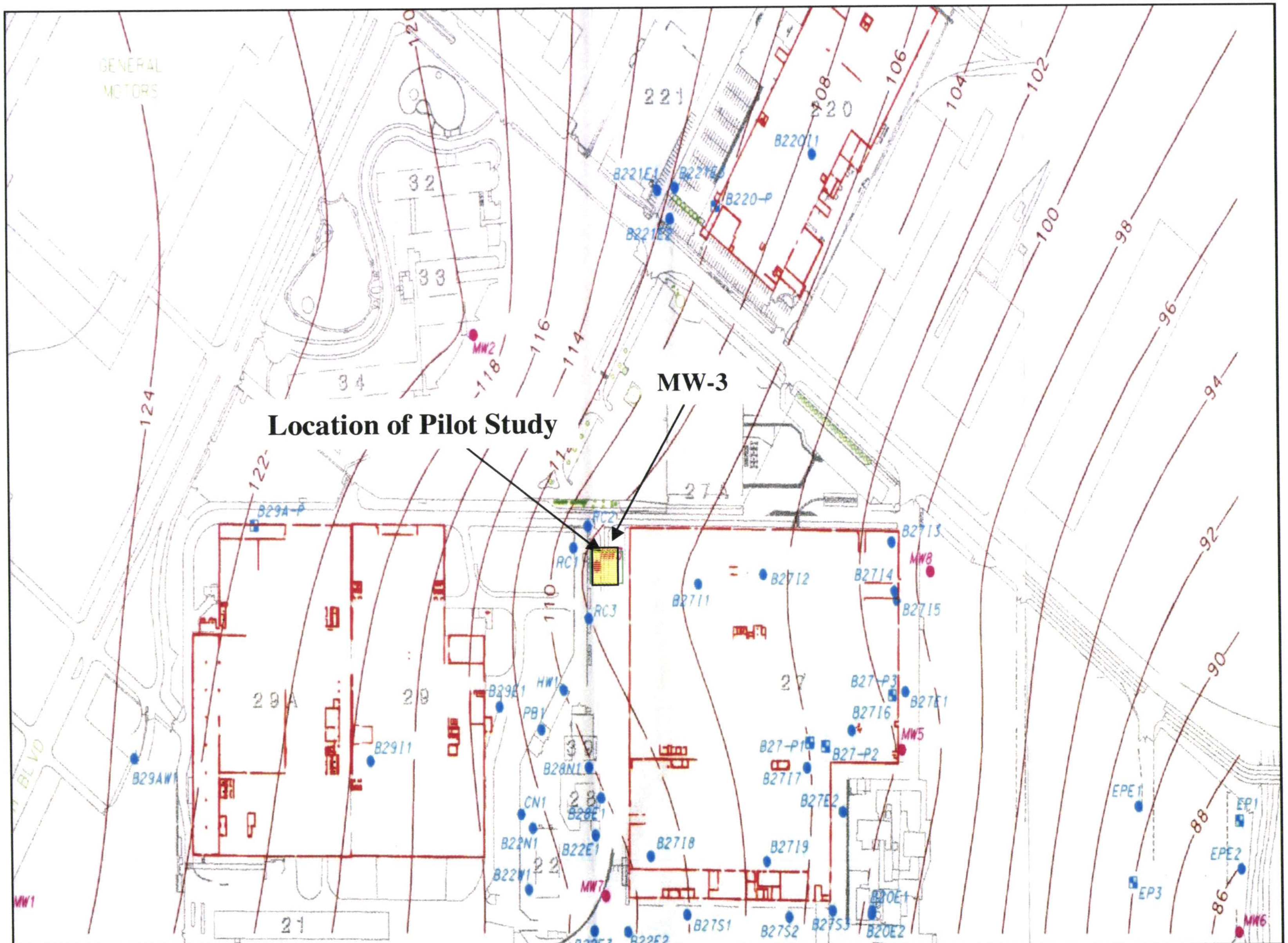
The area was selected around Monitoring Well 3 (MW-3) based on the high VOC concentrations. It exhibited the highest concentrations of TCE, 1,2-DCE, vinyl chloride, and 1,1-DCE levels for the shallow water-bearing unit. The field duplicate groundwater sample from MW-3 (254 ppb chromium) exhibited the only other concentration that exceeded a metals ITL for the swallow monitoring well network for the Phase 2B event. The proposed area is detailed in Figure 3-1 and Figure 3-2.

3.5.1 Injection Points

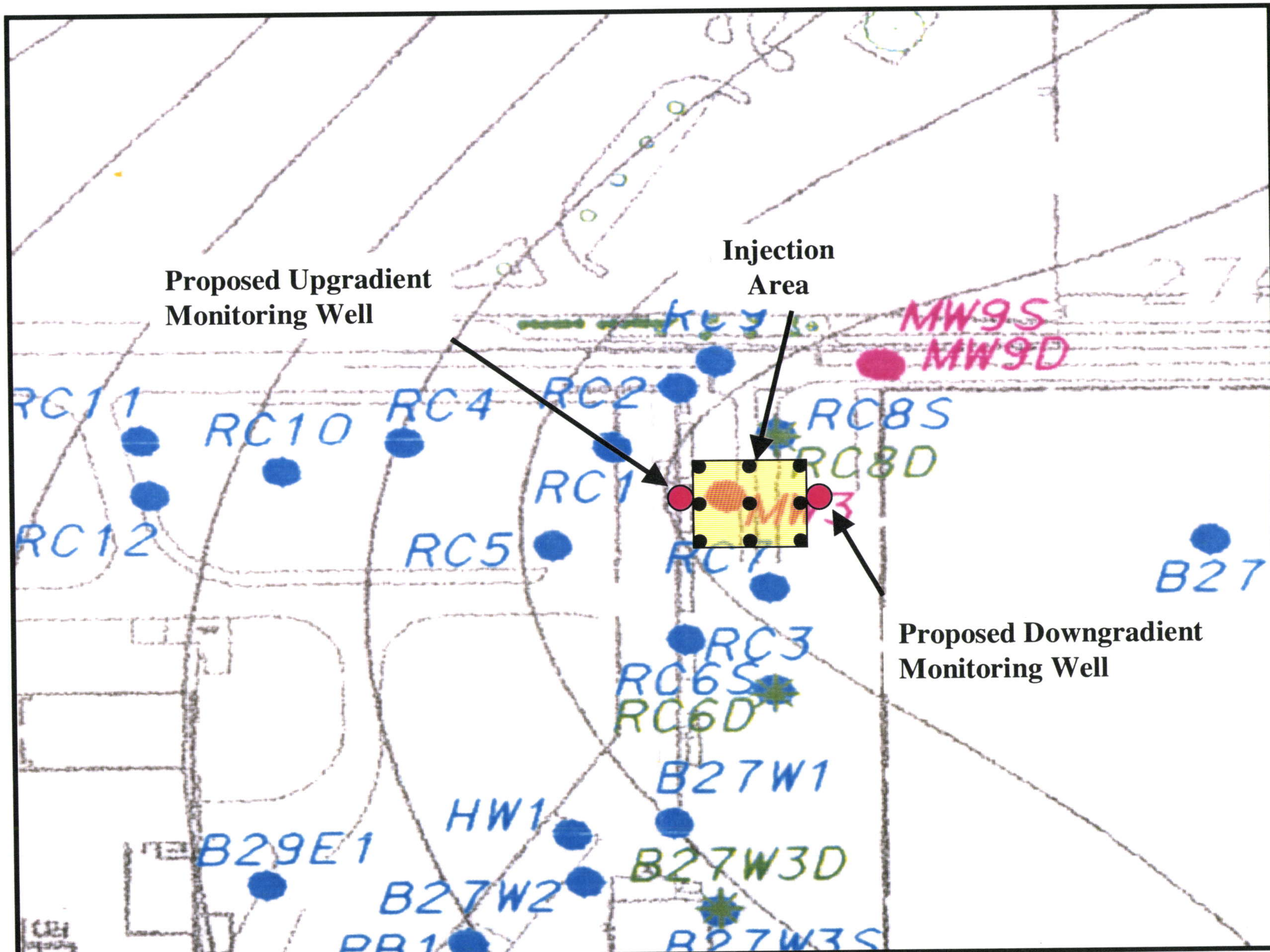
The proposed pilot study will apply the HRC in the shallow groundwater, between 8 and 28 feet below grade, in a 625 square foot area (approximately 25 feet by 25 feet). This area will be located in the immediate vicinity of MW-3. Depth to groundwater is between 8 and 12 feet below grade and the depth of the contaminated saturated treatment zone for MW-3 is 20 feet. The porosity of this area is 30 percent. Groundwater flow direction is variable, but generally to the southeast. Nine injection holes will be spaced on 10-foot centers in a grid pattern upgradient and around MW-3.

3.5.2 Monitoring Wells

Two additional monitoring wells will be installed to a depth equivalent to MW-3 at a location upgradient and one down gradient. Distance from MW-3 will be determined by underground utility concerns and enough separation to adequately monitor the pilot study area.



Boeing Pilot Study Workplan	Figure 3-1



Boeing Pilot Study Workplan | Figure 3-2

3.6 HRC Injection

The concentrations of contaminants used to calculate the amount of HRC to be applied is as follows: 5.4 mg/L TCE, 6.9 mg/L dichloroethene and .03 mg/L vinyl chloride. Additional competing electron acceptor values used to calculate the appropriate application rate are: 4 mg/L dissolved oxygen, 0.6 mg/L nitrate, 5 mg/L ferrous iron, and 60 mg/L sulfate. Additional Demand Factors were calculated for interstitial contaminants, competing microbial processes, and hydrophobic sorbtion based on the characteristics of the site. It is calculated that 843 pounds of HRC will be required to reduce the constituents of concern in the pilot area. A total of 6.7 pounds of HRC will be applied per linear foot between 8 and 28 feet below grade in 9 holes spaced on 10-foot centers in a grid pattern upgradient and around MW-3. Final grid pattern selection will depend on final verification of surrounding utilities.

The HRC will be injected under pressure into the subsurface through standard 1.25-inch direct push rods using a Geoprobe GS2000 pump or a Rupe model 9-1600 pump or equivalent equipment. It is estimated that it will take two working days to inject the material.

3.7 Equipment and Materials

A Geoprobe Drilling Unit will be used for the injection points using the direct push method. A Geoprobe GS2000 pump or equivalent equipment will be used in conjunction with the Geoprobe drill to inject the HRC under pressure through the 1.25 inch direct push rods.

4.0 Sampling and Analysis

4.1 Sample Collection Procedures

4.1.1 Groundwater Sampling

Groundwater will be sampled using low flow sampling techniques. All three monitoring wells will be sampled each month with summaries of data collected provided to MODNR every three months. Analytical constituents would include VOC constituents, redox potential, dissolved oxygen, nitrates, sulfates, metabolic acids, permanent gases, and ferrous iron . All samples will be evaluated for selected field criteria (temperature, pH, and conductivity) and then submitted for laboratory analysis of the above constituents.

4.1.2 Soil Sampling

Soil samples will be collected at the end of the pilot study to provide data regarding the effectiveness of the technology in the unsaturated unit. Analytical constituents will include VOCs, nitrates, sulfates, and metabolic acids. Samples will be collected from the unsaturated unit at a depth interval of approximately 10-14 ft bls.

4.2 Quality Assurance /Quality Control Samples

Groundwater samples will be collected and analyzed as previously described in the Phase 2 ESA Quality Assurance Project Plan. One duplicate groundwater sample will be collected on a quarterly basis and submitted for laboratory analysis. The selected laboratory will perform the laboratory analyses as required by this pilot study plan.

4.3 Sample Management, Preservation, & Chain-of-Custody Procedures

Immediately upon collection, each sample will be properly labeled to prevent misidentification. Samples collected for organic analysis will be placed in a shipping container with sufficient ice or ice packs to maintain an internal temperature of four-degrees Celsius during transport to the laboratory. A completed chain-of-custody form will be placed in each shipping container to accompany the samples to the laboratory. Shipping containers will be sealed with several strips of strapping tape. The required sample preservation methods for the specific constituents will be used for each monthly groundwater sample.

4.4 Equipment Decontamination Procedures

All drilling and sampling equipment will be decontaminated prior to use at the pilot study site. Decontamination of Geoprobe equipment and other pieces of equipment will be performed at the drilling location. Rinse waters will be collected in a drum.

To prevent possible cross-contamination between samples, all sampling tubes, pumps and other equipment will be decontaminated between monitoring wells. Decontamination procedures for sampling equipment will consist of a wash of an Alconox solution, a potable/tap water rinse, followed by a distilled water rinse.

5.0 Health and Safety

All Pilot Study tasks performed at the facility shall be conducted in accordance with the prior site-specific Health and Safety Plan (HASP) dated July 2000. The HASP will comply with the OSHA specifications contained in 29 CFR 1910.100. Boeing Safety and Environmental personnel will review the Health and Safety Plan to ensure completeness.

6.0 Evaluation of Test Results

Ground water samples will be taken each month during the anticipated 9 months of the pilot study. Soil samples will be taken after completion of the groundwater study to evaluate the effect on the unsaturated zone. Based on successful results of the HRC pilot study, data will be consolidated in to a final report. It is anticipated the Final Report will incorporate the following information:

- Plots and tables to evaluate progress
- Discussion of periodic progress reports
- Identification of approximate biodegradation rate, and
- Approximate timeframe to obtain remediation goals.

This report will be used to support the Boeing Remedial Action Plan.

7.0 Schedule

Submit pilot study workplan and injection application to MODNR by July.

Once approval of workplan and injection permit is received from MODNR, quotes for contractor selection will be requested by Boeing.

Proposals received after thirty days, reviewed by Boeing and a purchase order issued to the selected contractor.

Utility search conducted in pilot study location and date set for additional monitoring well installation and HRC injection.

Conduct anticipated 9-month pilot study.

Submit quarterly sampling analysis summaries to MODNR.